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## World-wide inventory of the status of 3D Cadastres in 2010 and expectations for 2014

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### 1. INTRODUCTION

In this paper, the background, set-up, and a preliminary analysis of the survey conducted by the FIG joint commission 3 and 7 working group on 3D-Cadastre<sup>32</sup>, 2010-2014 is presented. The purpose of the survey is to make a world-wide inventory of the status of 3D-Cadastres at this moment (November 2010) and the plans/expectations for the near future (2014). Sharing this information improves cooperation and exchange of experiences and supports future developments in different countries and cadastral jurisdictions. The FIG working group will repeat the survey in four years time to evaluate the actual progress. In the questionnaire the concept of 3D-Cadastres with 3D parcels is intended in the broadest possible sense.

At the FIG Congress in April 2010 in Sydney it was decided to form again a working group on 3D-Cadastres in order to make further progress with the subject; see Section 2 for more details of this working group. The registration of the legal status in complex 3D situations will be investigated under the header of 3D-Cadastres. Starting point of the working group is the observation that increasingly information is required on rights, use and value in complex spatial and/or legal situations.

There are several 3D-Cadastre scoping options, which will be investigated in more detail by the working group, and the result will define the scope of the future 3D-Cadastre in a specific country:

1. What are the types of 3D cadastral objects that need to be registered? Are these always related to (future) constructions (buildings, pipelines, tunnels, etc.) or could it be any part of the 3D space, both airspace or in the subsurface?
2. In case of (subsurface) infrastructure objects, such as long tunnels (for roads, metro, train), pipelines, cables: should these be divided based on the surface parcels or treated as one cadastral object.
3. For the representation (and initial registration) of a 3D cadastral object, is the legal space specified by its own coordinates in a shared reference system or is it specified by referencing existing topographic objects/boundaries.

The working group will focus primarily on professionals involved in geo-information and cadastral issues in 3D. This community will also provide the contributors to the working group. Access to this interest group is open to all. Once the results become more tangible the FIG-community at large will be our public.

Within the working group the concept of 3D-Cadastres with 3D parcels is intended in the broadest possible sense. 3D parcels include land and water spaces, both above and below surface. However, what exactly is (or could be) a 3D parcel is dependent on the legal and organizational context in the specific country (state, province).

<sup>32</sup> In the past decade various activities have been conducted related to 3D-Cadastres. The start of the international awareness of this topic was marked by the workshop on 3D-Cadastres, organized by Delft University of Technology in November 2001. This was followed by virtually a session at every FIG working week and congress afterwards (stimulated by the 2002-2006 FIG working group on 3D-Cadastres).



## 2. RESEARCH TOPICS

The working group identified four main research topics:

- **3D-Cadastrals and models:** It is important to realize that for registration, for storage/validation and for dissemination different models (all based on the shared ISO Land Administration Domain Model semantics) may be needed and different types of users are involved. The modelling aspect includes the question of which spatial (esp. height) and temporal information should be used and how different types of users may interact (i.e. produce, archive, edit, analyze, and visualize, edit) with 3D-Cadastre?
- **3D-Cadastrals and SII:** The registration of legal objects (cadastral parcels and associated rights) and their physical counterparts (e.g. buildings or tunnels) result into two different, but related data sets, which can be very well accessed together via the Spatial Information Infrastructure (SII, sometimes also called SDI). This is already true in 2D, but even more so in 3D.
- **3D-Cadastrals and time:** A 4D parcel is defined as the spatio-temporal unit against which (one or more) unique and homogeneous rights (e.g. ownership right or land use right), responsibilities or restrictions are associated to the whole entity, as included in a Land Administration system. Homogenous means that the same combination of rights equally apply within the whole 4D spatial temporal unit. Unique means that this is the largest spatio-temporal unit for which this is true. Making the unit any larger (in 3D space or time) would result in the combination of rights not being homogenous.
- **3D-Cadastrals and usability:** The graphic user interface is an essential aspect when realizing 3D-Cadastrals in practice. This includes investigation of interacting with true 3D cadastral data (specific user interfaces: 3D spatial and perhaps temporal aspects via animations or snapshot sliders). The existing quality of successful and popular user interfaces (e.g. Google Earth, see Figure 1) will be the starting point with specific attention for working with the main 3D legal object types (related to underground infrastructure and building/apartment complexes).

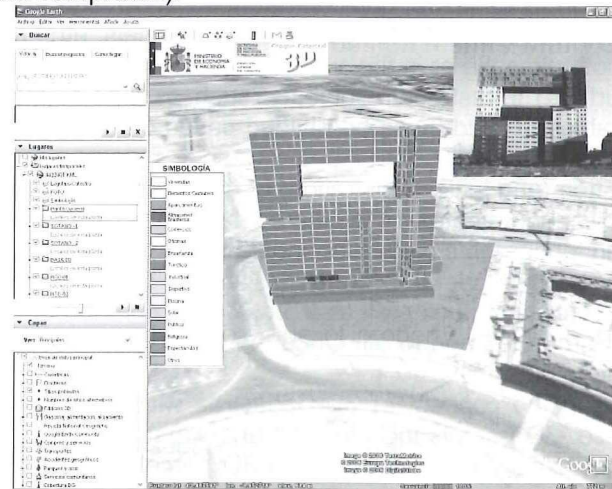


Figure 1. 3D visualisation in Google Earth (example Spanish cadastre)

A true 3D cadastral system with functions should be implemented and applied to demonstrate the possibilities in practice based on 3D visualization. How to distribute the 3D cadastral information to the citizens? How to represent and demonstrate the 3D geographic aspect?

The working group strives to obtain tangible results that have relevance to the cadastral practice. At the next FIG congress (2014) we want to publish a FIG publication on guidelines to establish 3D-Cadastrals (a 'Primer on 3D-Cadastrals'), addressing legal, institutional and technical issues. In 2011 a second workshop on 3D-Cadastrals is planned (again in Delft, 10 years after the first workshop). In addition, at the FIG working weeks joint commission 3 and 7 sessions on 3D-Cadastrals will be organized.

Communication during the projects will be done as much as possible by e-mail and via our dedicated website: [www.gdmc.nl/3DCadastrals](http://www.gdmc.nl/3DCadastrals).

## 3. DESIGN OF THE QUESTIONNAIRE

The first page of the questionnaire contained a few notes (including an informal and a formal definition of a 3D parcel) and suggestions, which should be helpful during the completing.

The formal definition a 3D parcel is defined as the spatial unit against which (one or more) unique and homogeneous rights (e.g. ownership right or land use right), responsibilities or restrictions are associated, as included in a Land Administration system. As this definition is quite abstract, the questions were phrased with more descriptive and real world situations included to explain further.

The questionnaire specifically aims at clarifying the difference between 3D legal space (referred to as 3D parcel) and 3D physical objects. A 3D parcel is a 'legal object' describing a part of the space. Often there is a relationship with a real world/physical object, which can also be described in 3D, but this is not invariably the case. The questionnaire was framed to recognise the difference between these two types of objects and that the focus in the context of 3D-Cadastrals is on 3D parcels (spaces of legal objects). The questionnaire was grouped in nine different thematic blocks: (1) general/applicable 3D real-world situations; (2) infrastructure/utility networks; (3) construction/building units; (4) X/Y Coordinates; (5) Z Coordinates/height representation; (6) temporal issues; (7) rights, restrictions and responsibilities; (8) Digital Cadastral Database and (9) Plans of Survey.

The first group of questions refers to the applicable 3D real-world situations to be registered by 3D parcels. It also addressed the types of 3D geometries, which are considered to be valid 3D representations for these parcels. The second group of questions refers to the situation where an infrastructure network is considered to be defined within the cadastre. The third group of questions refers to 3D properties that are related to constructions and apartment (condominium) buildings. The individual units are often defined by the actual walls and structure of a building, rather than by metes and bounds. The other 6 groups of questions are more or less self-evident. Finally, group 10 the contact details could be provided together with any other issue that was relevant, but not yet addressed by one of the earlier questions.

## 4. PRELIMINARY ANALYSIS OF THE RESPONSES

36 completed questionnaires have been received and they are all available at the working group website. From the completed questionnaires we received, a number of conclusions can be made. The first is that despite all the research in the past year the concepts "3D cadastre" and "3D parcels" are still ambiguous. The completed questionnaires offer therefore in the first place an overview of the very different ways in which systems of land administration deal with the third dimension of rights (or restrictions). Worldwide there are major differences in those systems, mostly the result of cultural and historical differences in background, and these differences influence the organizational, technical and legal aspects of land registration. Because of these differences, a comparison of the responses is not always easy.

A general conclusion is that in all jurisdictions, with the exception of Poland and Nepal, 3D parcels can be registered. But in most cases these 3D parcels are (or even limited to)



apartment units. That it is not possible to register 3D parcels other than apartment units in a specific land administration does not mean automatically that it is not possible to create rights that are limited in the third dimension. E.g. in the case of South Korea the respondent explicitly indicated that 3D boundaries of rights are possible by civil law, while cadastral regulation does not touch this subject. In the following paragraphs we give an overview of the preliminary analysis of survey results for several aspects.

#### 4.1 Are all 3D parcels constrained to be within one surface (2D) parcel?

Most respondents replied on question 1.1 of the questionnaire that a 3D parcel must be located within the boundaries of a (2D) parcel. This does not exclude that the building to which the right refers may be situated on several land parcels. Possibly - as in the case of the Netherlands - a legal 3D description of right refers to various 2D land parcels. The responses are not always clear on the question what will happen if the land parcel is subdivided later. In Queensland it is the starting point that the 3D parcel must be within the boundaries of a 2D parcel, but this does not exclude that the 2D parcel may be subdivided later on. After subdivision the original 3D parcel continues to exist and therefore stretches out over two or more land parcels. In Norway and Sweden, 3D properties may be created that extend over or under different 2D parcels. In Finland this possibility is foreseen for the future.

#### 4.2 Empty spaces or existing constructions?

An interesting question is whether registration of rights to empty spaces - such as air spaces or subsurface volumes - is allowed (e.g. to protect an existing panorama) or that the registered right compulsory refers to an existing or future construction. The responses shows that in most countries explicit rules for this do not exist, but also indicated that in general the rights will refer to a construction. Explicitly the possibility of registration of rights for empty spaces are mentioned in Australia and Canada (Quebec), In Finland this is limited to subsurface volumes. By contrast, Norway and Sweden the law expressly exclude this possibility. In these countries there must be a construction, or a building permit issued for future constructions before a 3D property can be registered. In Norway 3D parcels can be nullified in the case construction has not started building the construction that is going to be the 3D property three years after the building permit has been issued.

#### 4.3 Boundaries of the 3D parcel

Generally the boundaries of 3D parcels refer to walls, ceilings and floors. The respondent for France expressly states that - in the absence of guidelines in this area - virtual boundaries would be possible. With respect to the z-axis (height) it appears that in the vast majority of systems directives on this issue does not exist or the height is not registered. Among the countries that do register the height (in survey plans or in a legal deed) it may be observed that Australia and France make use of an absolute level while in Canada (Quebec) and Sweden reference is made to a height relative to ground level.

#### 4.4 Registration of 3D parcels in the cadastral database

3D parcels as such do not exist in any cadastral registration. The description of the 3D space will be found in the survey plans or in the legal documents. The standard seems to be that "floorplans" that the boundaries per floor are listed in the title deed or the appropriate public records (Land Book, Land Registry, public records) or survey plans but not in the cadastral database (map). It may be possibly a make a reference to the 3D parcel in the cadastral map

in the form of a 2D polygon in a single layer as in the case of Australia, Cyprus, Croatia (where is spoken of a "2.5D representation"), Norway and Sweden.

In Italy 3D Cadastre in Italy is represented by the Cadastre of Buildings, that exists next to the "Land Cadastre". This holds an inventory of every building. A very interesting system of 3D registration exists in Spain. Here on the cadastral map a 3D model of the buildings can be shown, including the boundaries of rights inside the buildings. But this is not a 3D representation of the actual height of the units. In fact the representation is based on a standard height of 3 meters from floor-to-floor.

#### 4.5 Registration of cable and pipeline networks

Cable and pipeline networks occupy a special place within the registered 3D objects and rights. These networks often extend over several land parcels and thus have - apart from the height or depth of the structure - a 3D character of their own. In recent years the Netherlands introduced the possibility to register rights to all types of cable and pipeline networks. The networks have a cadastral number of their own. In Switzerland, especially in Geneva networks are included in the cadastral database in a similar way. In the Russian Federation, a network can be registered by the Land Registry, but in practice this is not done. In Kazakhstan, all networks are registered "as legal objects". However the respondent also mentions that underground networks are not registered but only shown on maps. Furthermore, in Canada (Quebec) cable and pipeline networks, rail networks are recorded in public registers (Register or real right of State resource development). It can be requested by the owner that the network is displayed on the cadastral plan, but this rarely happens. The network as such can not be found in the cadastral database, but indirectly through the land parcels in which the network is constructed. In other countries registration of networks does not happen, or is just possible in limited cases, as in Turkey where only high voltage power lines are registered in the cadastral database. Registration of other networks find place at municipal level, and combined with cadastral data. A general registration of (underground) networks does not exist in Norway, where telecommunications, water and electricity networks are not registered, but roads and railways are. Some jurisdictions have "utility maps" (Australia, Victoria) or a "utility register" as Croatia. In the latter country is expected that this register will be integrated in the cadastral database in 2014. Also in other countries we see developments towards the cadastral registration of networks, especially in Denmark, Hungary, Israel and Italy.

#### 4.6 Developments in the short term

The purpose of the survey by the FIG Working group was not only to make a world-wide inventory of the status of 3D-Cadastrals at this moment (2010/2011), but also to get an insight in the expectations for the near future (2014). However, the planned developments in the field of 3D cadastre for 2014 seem to be very limited. Whether this means that one is satisfied with the existing system of 2D registration, like the respondent for England and Wales expressly stated, remains unclear. The vast majority of respondents did not answer the questions one the expected situation for 2014. The most concrete developments seems to happen in Switzerland, where in 2014 the concept of 3D plots might be introduced, and Denmark, where the respondent mentions an ongoing discussion of 3D parcels should be recorded in the cadastre and a footprint on the cadastral map. Bahrain mentions the future representation of the apartments in the cadastral database. In recent years in Israel there has been much research into the development of a 3D cadastre and preparations aimed at legislation and it is hoped that this will result in practical changes.



## 5. CONCLUSION AND FUTURE WORK

As indicated, the solutions for registration of rights with 3D characteristics are very different. Broadly, one can observe that apartments are registered with drawings in the deed registration. But a true 3D registration in the cadastre does not exist anywhere.

Techniques for 3D data acquisition, management and distribution will be within reach. The next step is to optimally exploit this in order to meet the growing information needs in 3D cadastres, matching specific organizational and legal contexts. The international approach of the FIG working group hopes to make an important contribution to reach this, by the publication of "Primer on 3D-Cadastres" providing guidelines for specific contexts and implementations, addressing legal, institutional and technical issues.

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**Peter van Oosterom** obtained an MSc in Technical Computer Science from Delft University of Technology, The Netherlands. In 1990 he received a PhD from Leiden University. From 1985 - 1995 he worked at TNO-FEL in The Hague, The Netherlands. From 1995 - 2000 he was senior information manager at the Dutch Cadastre. Since 2000, he is professor at Delft University of Technology. He is chair of the FIG working group on '3D-Cadastres'.

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**Hendrik Ploeger** studied law at Leiden University and the Free University of Amsterdam, The Netherlands. In 1997 he finished his PhD-thesis on the subject of the right of superficies and the horizontal division of property rights in land. He is associate professor at Delft University of Technology (OTB Research Institute) and holds the endowed chair in land law and land registration at VU University of Amsterdam.

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